Response of seedlings growth of *Pinus sylvestriformis* to atmospheric CO_2 enrichment in Changbai Mountain

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Abstract The biomass and ratio of root-shoot of *Pinus sylvestriformis* seedlings at CO_2 concentration of 700 $\mu L \cdot L^{-1}$ and 500 $\mu L \cdot L^{-1}$ were measured using open-top chambers (OTCs) in Changbai Mountain during Jun. to Oct. in 1999. The results showed that doubling CO_2 concentration was benefit to seedling growth of the species (500 $\mu L \cdot L^{-1}$ was better than 700 $\mu L \cdot L^{-1}$) and the biomass production was increased in both above-ground and underground parts of seedlings. Carbon transformation to roots was evident as rising of CO_2 concentration.

Key words: *Pinus sylvestriformis,* Biomass allocation, Atmospheric CO_2 enrichment

Introduction

Global change has been one of the important issues and scientists pay close attention to it. The great importance of forest ecosystem is reflected not only by their huge biomass, but also by their significant role in the global carbon balance. How trees respond to climatic changes might be of great significance.

Many studies indicate that the rising atmospheric CO_2 levels can make a substantial effect on plant growth and development. Someone think commonly that the rising CO_2 levels can stimulate plant growth and biomass production, since photosynthesis of C_3 plants is not saturated at the present ambient CO_2 concentration, if other environmental factors are not limiting (Schwanz *et al.* 1996). The leaf area may become significantly larger (Rogers *et al.* 1994), root-to-shoot ratio changes (Ceulemans & Mousseau, 1994; Norby & O'Neill 1991), and length and weight of stems increase (Bazzaz, 1990) with rising of CO_2 concentration.

Changbai Mountain is an important ecological research site for its various natural ecosystems and rich gene pool. It has played an important role in International Long-Term Ecological Research Network (LTER) since 1993. Study on the effects of a doubling of CO_2 concentration on the trees growth will have great significance for the earth's energy budget and the global carbon balance.

In this study we chose the seedlings of *P. sylvestriformis* to research the growth response to elevated CO_2 concentration by Open-Top Chambers (OTCs).

Materials and methods

Study site is located at Changbai Mountain. The seeds of *P. sylvestriformis* were pretreated in spring and removed into OTCs in the early May. Using forest soil replaced the soil in chambers. The new soil depth was about 0.5 m. The fumigation of seedlings by CO_2 gas in the chambers started in the middle June and stopped at the end of seedlings growing.

OTCs are a series of boxes composed of glasses and frames of structural alloy steel. The thickness of glasses is 3 mm and has little influence on luminous flux. The size of box is 1.2 m $\times$0.9 m $\times$0.9 m.

Three chambers were adopted in the experiment. Of which, two chambers with elevated CO_2 treatment were respectively maintained at 700 $\mu L \cdot L^{-1}$ and 500 $\mu L \cdot L^{-1}$ and one chamber with ambient air was used to determine effect of thermal radiation. A control site with no chamber was set to contrast with the chambers. All of sites were watered daily at 8:00 a.m. and 3:00 p.m. the water-stressed of seedlings were rarely happen except the specific aim needed.

Results

Growth changes of seedlings in different seasons were shown in Table 1. It included the biomass, carbon allocation to above- and under-ground. The biomass is an average value of measurement. Temperature is an average of five days, measured at 6:00 a.m., 10:00 a.m. 14:00 p.m. and 18:00 p.m.

In the experimental process, it was found that the temperature effect on the growth of seedlings was not remarkable. This may be because of that the increase of temperature was not evident.

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By comparing the biomass of seedlings in the chamber with that in the nature field, it was clear that the elevated CO_2 concentration increased the growth of seedlings (Fig. 1) and the variation of ratio root/shoot was evident except that in the initial stage of seedlings growing.

Table 1. Measurements of the biomass of seedling of *P. sylvestriformis* at a doubling of CO_2 concentration

Samples	Measured time	Dry weight /g	Biomass Above/under	Temp. /℃
OTC-700 μL·L^{-1}	2 Jul.	0.029	0.025/0.004	30.6
OTC-500 μL·L^{-1}	-	0.043	0.035/0.008	28.9
OTC-Air	-	0.026	0.020/0.006	29.8
Contrast-Air	-	0.048	0.038/0.010	28.0
OTC-700 μL·L^{-1}	24 Jul.	0.078	0.061/0.017	32.0
OTC-500 μL·L^{-1}	-	0.102	0.080/0.022	30.0
OTC-Air	-	0.069	0.056/0.013	29.5
Contrast-Air	-	0.058	0.044/0.014	29.0
OTC-700 μL·L^{-1}	25 Aug.	0.167	0.127/0.040	
OTC-500 μL·L^{-1}	-	0.214	0.155/0.059	
OTC-Air	-	0.127	0.091/0.036	
Contrast-Air	-	0.117	0.083/0.034	
OTC-700 μL·L^{-1}	22 Sep.	0.244	0.168/0.076	
OTC-500 μL·L^{-1}	-	0.324	0.221/0.103	
OTC-Air	-	0.180	0.130/0.050	
Contrast-Air	-	0.160	0.113/0.047	

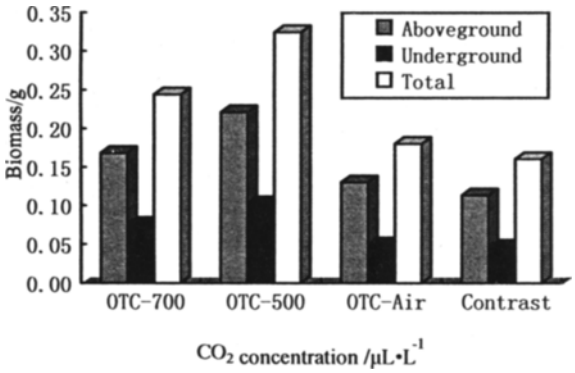

Fig. 1. Biomass changes at different CO_2 concentration

Table 2 was woven according to the ratio of underground to total biomass. We could see that the carbon transformation to roots was evident as rising of CO_2 concentration.

Table 2. The biomass allocation of seedling at the elevated CO_2 concentration

Samples	July %	Underground/Total August	September (%)
OTC-700 μL·L^{-1}	22	24	32
OTC-500μL· L^{-1}	21	28	32
OTC-Air	19	28	28
Contrast-Air	24	29	29

Conclusions

P. sylvestriformis as an important species in Changbai Mountain is sensitive to doubling CO_2 concentration. Study results showed that doubling CO_2 concentration was benefit to seedling growth of the species and the biomass production increased in both aboveground and underground parts of seedlings. Carbon transformation to roots was evident as rising of CO_2 concentration.

References

Bazzaz, F.A. 1990. The response of nature ecosystems to the rising global CO_2 levels. Annu. Rew. Ecol. Syst., **21**: 167-196.

Ceulemans, R. and Mousseau, M. 1994. Tansley review No. 71 Effects of elevated atmospheric CO_2 on wood plants. New Phytol., **127**: 425-446.

Havelka, U.D., Ackerson, R.C., Boyle, M.G., and Wittenbach, V.A. 1984. CO_2-enrichment effects on Soybean physiology. I. Effects of long-term CO_2 exposure. Crop Science, **24**: 1146-1150.

Han Shijie. 1996. Eco-boundary Layer Ecology for Leaves. Northeast Forestry University Press. Harbin, China. (in Chinese)

Kimball, B.A. 1992. Cost comparisons among free-air CO_2 enrichment, open-tops chamber, and sunlit controlled-enrichment chamber methods of CO_2 exposure. Critical Review in Plant Sciences, **11** (2-3): 265-270.

Lipfert; F.W. *et al.* 1992. Performance analysis of the BNL FACE Gas Injection System. Critical Review in Plant Sciences, **11**(2-3): 143-163.

Morison, J. I. L. 1987. Intercellular CO_2 concentration and stomatal response to CO_2. Stanford University Press. Stanford, California.

Norby, R.J. 1994. Issues and perspectives for investigating root responses to elevated atmospheric carbon dioxide. Plant and Soil, **165**: 9~20.

Norby, R.J., O'Neill, E.G. 1991. Leaf area compensation and nutrient interaction in CO_2-enriched seedlings of yellow poplar. New Phytologist, **117**: 515~528.

Poorter, H. 1993. Interspectific variation in the growth response of plants to an elevated ambient CO_2 concentration. Vegetatio, **104/105**: 77-97.

Rogers, H.H., and Runion, B. 1994. Plant response to atmospheric CO_2 enrichment with emphasis on roots and the rhizosphere. Environmental Pollution, **83**: 155-189.

Schwanz, P. *et al.* 1996. Interactive effects of elevated CO_2, ozone and drought stress on the activities of antioxidative enzymes in needless of Norway *Spruce* trees grown with *Luxurious* N-supply. J. Plant Physiol., **148**: 351~355.